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# My mother is sensitive, but I am too tired to know: Infant sleep as a moderator of prospective relations between maternal sensitivity and infant outcomes

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ABSTRACT

This study investigated the moderating role of infant sleep in the connections between maternal sensitivity and three indicators of infant functioning: attachment security, theory of mind, and executive functioning (EF). Maternal sensitivity was assessed when infants (27 girls and 36 boys) were 1 year of age. Infant sleep was assessed with actigraphy at age 2; attachment security, theory of mind, and EF were also assessed at age 2. Results indicated that maternal sensitivity was positively related to attachment security only among infants who got more sleep at night, and to conflict-EF and theory of mind only for infants who got greater proportions of their sleep during the night. These results suggest that sleep may enhance the benefits of maternal sensitivity for some aspects of infants' functioning, providing further support for the importance of sleep maturation as a salient developmental task of infancy.



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A central question in contemporary developmental science pertains to the conditions under which early experience relates to subsequent child functioning. Perhaps the most salient aspect of early experience during infancy and toddlerhood concerns parent-infant interactions. A long history of empirical research has documented reliable associations between the quality of parent-infant interactions and child outcomes (Grossmann, Grossmann, & Waters, 2005). However, much of this research has shown substantial variability in this relation (see Ellis, Boyce, Belsky, Bakermans-Kranenburg, & Van IJzendoorn, 2011; Thompson, 2008), suggesting that other factors may moderate this link. In fact, both classic theories (e.g., Monroe & Simons, 1991) and recent conceptualizations (Belsky & Pluess, 2009; Boyce & Ellis, 2005) contend that children's biological

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characteristics and physiological regulation may interact with relationship processes in predicting child outcomes. This view is increasingly supported by empirical evidence demonstrating that the magnitude of the links between different aspects of parent-child relationships and a vast array of child outcomes varies according to child biologically-based characteristics (e.g., Crockenberg & Leerkes, 2006; Kochanska & Kim, 2013; Spangler, Johann, Ronai, & Zimmermann, 2009).

One aspect of young children's biological regulation that has drawn researchers' attention in recent years is sleep. Like other biological factors, sleep has been proposed to play a modulating role in children's receptivity to caregiving influences (El-Sheikh, Hinnant, Kelly, & Erath, 2010). This hypothesis, however, remains largely unexamined. Accordingly, the current report investigates the moderating role of infant sleep in the associations between the quality of mother-infant interactions and three important indicators of child functioning: attachment security, theory of mind, and executive functioning.

## 1. Early parent-infant relationships and child development

Decades of empirical research have provided overwhelming support for the classic assumption that early parent-infant relationships influence child development. As documented by longitudinal studies spanning over more than 20 years of development (see Grossmann et al., 2005), by meta-analytic reviews (e.g., Fearon, Bakermans-Kranenburg, Van IJzendoorn, Lapsley, & Roisman, 2010), and by experimental studies (Guttentag et al., 2014; Kochanska, Kim, Boldt, & Nordling, 2013), the quality of early caregiving relationships lays a foundation for child development in all central domains of functioning, including socio-emotional (Leerkes, Blankson, & O'Brien, 2009), cognitive (Tamis-LeMonda, Bornstein, & Baumwell, 2001), and psychobiological (Oosterman, De Schipper, Fisher, Dozier, & Schuengel, 2010). However, meta-analyses converge in highlighting that the links between different aspects of parenting and child functioning, while numerous and robust, are moderate in magnitude (e.g., McLeod, Wood, & Weisz, 2007; Rothbaum & Weisz, 1994). One possible interpretation of such findings is that not all children respond to parenting in the same way, suggesting that other factors may attenuate or exacerbate the effects of parenting on children. Theory and recent research suggest that child biological characteristics may play such a moderating role in the parenting-child outcome associations (see Ellis et al., 2011). Among the markers of biological regulation that might be considered in this respect is sleep.

## 2. Sleep and self-regulation

There is a long tradition of sleep research with infants and children conducted from a medical perspective, studying clinical populations such as premature babies (Anders & Keener, 1985) or sleep-disordered infants (Anders & Weinstein, 1972). While much has been and continues to be learned from this pediatric perspective, recent years have also seen the emergence of a body of developmental sleep research, focusing on normative variation in sleep patterns among typically-developing children (see El-Sheikh, 2011). As a result, the role of sleep in promoting or undermining children's capacity to regulate emotions and behavior is now well demonstrated, especially among school-age children (see Astill, Van der Heijden, Van IJzendoorn, & Van Someren, 2012; Gregory & Sadeh, 2012). Much of this research, however, has used parental reports of child sleep, which tend to overestimate sleep duration markedly (Simard, Bernier, Bélanger, & Carrier, 2013; Werner, Molinari, Guyer, & Jenni, 2008).

When considering younger children, some studies have used objective sleep measures with preschoolers (Hatzinger et al., 2010; Sheridan et al., 2013; Vaughn et al., 2011; Ward, Gay, Alkon, Anders, & Lee, 2008) and, quite rarely, with toddlers (Berger, Miller, Seifer, Cares, & LeBourgeois, 2012; Gribbin, Watamura, Cairns, Harsh, & LeBourgeois, 2012; Scher, Hall, Zaidman-Zait, & Weinberg, 2010). These latter reports confirm that sleep of higher quality and/or duration is linked to better functioning during infancy and toddlerhood. Scher et al. observed that infants and toddlers ($N = 27$) with more fragmented sleep displayed higher awakening cortisol levels compared to those with less fragmented sleep, while Gribbin et al. studied seven 2- to 4-year-olds and found that the normal morning cortisol awakening response was diminished after sleep restriction. Finally, Berger et al. reported that sleep restriction led to more negative and less positive emotionality while viewing emotion-inducing pictures or solving difficult puzzles among 30-to-36-month-old children ($N = 10$). Although very few and based on small samples, these studies converge with those conducted with older children in confirming the pivotal role played by sleep in infant and toddler self-regulatory capacities, whether biological or emotional.

## 3. Sleep as a moderator of parent-child relational processes

The regulatory function of sleep appears likely to play an important role in how children process and respond to their environment, which has led scholars to propose that sleep could contribute to shaping the psychological outcomes of children exposed to different environments (e.g., El-Sheikh et al., 2010). In Berger and colleagues' (2012) words, "sleepy children may view and respond to the world differently than children who are well rested; they may not be able to take full advantage of positive experiences" (p. 242). In this perspective, it is conceivable that adequate sleep serve a facilitating role in the unfolding of expected developmental processes, such as those linking early parenting to child adaptation. The restorative properties of adequate sleep may facilitate the expression of the levels of functioning that can be expected from children's prior caregiving experiences. Conversely, poor sleep, by hindering child current regulatory abilities, may impede children's capacity to display the developmental competence made possible by their earlier caregiving experiences. In other words, the quality of early caregiving relationships provides infants with a certain potential for functioning that will be expressed

as they develop; adequate sleep at later ages may serve to facilitate the expression of this potential, whereas poor sleep might constrain or otherwise interfere with this developmental legacy. Accordingly, the expectation is that sleep quality or duration can moderate the links between earlier caregiving experiences and concurrent measures of child functioning.

To our knowledge, only two studies have investigated the moderating role of child sleep in the links between parenting and child adaptation. Based on a sample partly overlapping with the current one, we found that higher maternal sensitivity was related to lower levels of subsequent externalizing and internalizing behavior problems as expected, however only among infants getting relatively more nocturnal sleep, suggesting that infants who slept more at night may have more greatly benefited from the protective influence of maternal sensitivity (Bordeleau, Bernier, & Carrier, 2012a). That study relied on maternal reports of infant sleep however, whereas it is increasingly recommended to use objective sleep measures such as actigraphy (Sadeh, 2011). We are aware of only one study that has done so. El-Sheikh et al. (2010) found that actigraphy-derived sleep duration and quality among school-aged children were significant moderators of the links between maternal psychological control and child internalizing symptoms. While children getting more adequate sleep and living in higher-SES families appeared to be protected against psychological control, those living in lower-SES homes rather seemed more vulnerable to the detrimental effects of maternal control when they got more adequate sleep, again suggesting that adequate sleep may make children more sensitive to their environment. However, as underscored by these authors, their study was cross-sectional and relied on child questionnaires to assess parental behaviors and internalizing symptomatology.

Hence, the two studies that have investigated the moderating role of infant or child sleep in the links between the quality of parental behavior and child outcomes converge in suggesting that in some circumstances, children showing indices of more adequate sleep may be more susceptible to caregiving. They each, however, presented significant measurement limitations, including reliance on maternal reports to assess child sleep, single-reporter data for parenting and child outcomes, or a cross-sectional design. From both methodological and conceptual perspectives, a longitudinal design in which the assessment of parent-infant interaction predates that of child outcomes is especially valuable in diminishing shared method variance and examining the presumed underlying developmental sequence. In addition, the studies by Bordeleau et al. (2012a) and El-Sheikh et al. (2010) both focused on child psychological symptomatology as their outcome, while there is ample evidence that parenting impacts many more domains of child functioning, and no theoretical reason to expect that putative interactive effects with child sleep would be limited to psychopathology.

This study aimed to contribute to the extremely young literature examining the moderating role of child sleep in the links between parenting and child outcomes, while addressing some of the gaps in prior research and broadening the scope of outcomes considered. Thus, this longitudinal study used an observational measure of maternal sensitivity along with an objective assessment of infant sleep to investigate if the relations between maternal sensitivity assessed at 1 year and infant attachment security, theory of mind and executive functioning, measured at age 2, are moderated by concurrent assessments of sleep at age 2.

In addition to constituting key indicators of three central pillars of child development (socio-emotional, socio-cognitive, and neuro-cognitive functioning, respectively), attachment, theory of mind, and executive functioning share reliable yet moderate connections to the quality of parent-infant interaction. Notably, meta-analytic work suggests that maternal sensitivity, the putative main precursor of infant attachment, accounts for only a moderate portion of the variance in attachment (De Wolff & Van IJzendoorn, 1997). Likewise, whereas several studies have shown links between certain aspects of maternal behavior and child theory of mind (Taumoepeau & Ruffman, 2008) or executive functioning (Bernier, Carlson, Deschênes & Matte-Gagné, 2012), others found non-significant relations (Landry, Miller-Loncar, Smith, & Swank, 2002; McElwain & Volling, 2004). These mixed findings may suggest that the links between the quality of parent-infant interaction and infant attachment, theory of mind, and executive functioning are modulated by other factors. Among other possible factors, sleep appears to represent a good candidate to play such a moderating role, given its robust relations to both social and cognitive functioning in young children.

Numerous studies have assessed attachment or executive functioning in infancy and toddlerhood; well-validated measures are therefore readily available and will be used here. In contrast, early investigations of theory of mind suggested that this ability developed around 4 years of age (Wellman, Cross, & Watson, 2001). There is increasing evidence, however, that certain aspects of theory of mind begin to develop much earlier, notably perspective-taking abilities. Research indicates that infants as young as 1 year of age (Luo & Baillargeon, 2007) can already take into account what objects an individual can see when predicting his or her actions. This capacity to understand others' visual perspectives is considered one of the building blocks of young children's theory of mind (Harris, 1996). Visual-perspective taking will therefore be used here as an index of infants' fledgling theory of mind abilities.

## 4. Pertinent sleep indicators in infancy and toddlerhood

A key aspect of the early development of the sleep-wake cycle is the consolidation of sleep into the night period (Anders & Keener, 1985). Total sleep duration decreases sharply over the second year of life, mainly because of a decrease in daytime sleep, leading to greater proportions of total sleep taking place at night (Acebo et al., 2005; Iglowstein, Jenni, Molinari, & Largo, 2003). This suggests that total 24-hour sleep duration may not be a developmentally adequate index of sleep in infancy or toddlerhood; the *duration and proportion of nighttime sleep* appear more likely to reflect meaningful individual differences at that age. In fact, the proportion of nighttime sleep among infants and toddlers has been reported by different teams to be more clearly related to developmental outcome than other sleep indicators (e.g., Bernier, Beauchamp,

Bouvette-Turcot, Carlson, & Carrier, 2013; Dionne et al., 2011). In contrast, infant total sleep duration has been found unrelated to expected antecedents (e.g., Tikotzky, Sadeh, & Glickman-Gavrieli, 2011), suggesting its unclear meaning. Therefore, in order to investigate whether poor sleep can interfere with infants' capacity to display the levels of functioning predicted from their earlier caregiving experiences, this study examined the links between maternal sensitivity at 1 year of age and infant outcomes at age 2, as moderated by age-2 nighttime sleep duration and proportion of total sleep taking place at night.

It was expected that current sleep indices would interact with earlier maternal sensitivity in the prediction of infant attachment security, perspective-taking abilities, and executive functioning, such that the expected links between sensitivity and outcomes would be greater among infants getting relatively more sleep at night and greater proportions of their total sleep during the night.

## 5. Method

### 5.1. Participants

Families were recruited from random birth lists of a large Canadian metropolitan area provided by the Ministry of Health and Social Services. Inclusion criteria were full-term pregnancy and the absence of any known disability or delay in the infant. The sample consisted of 63 infant-mother dyads, 27 girls and 36 boys. To ensure independent assessments of predictor and outcomes and in keeping with the putative underlying developmental process, two home visits were conducted, when infants were 1 (T1; $M$ = 12.5 months; $SD$ = .9) and 2 years of age (T2; $M$ = 25.4 months; $SD$ = 1.1). Mothers were between 20 and 44 years old ($M$ = 31.8); most of them had a college degree (61.9%; 15.2 years of education on average) and were Caucasian (87.3%). Nearly all mothers (98.4%) were married to or living with the child's father throughout data collection. Family income varied from less than $20,000 to more than $100,000.

### 5.2. Procedure

The first visit took place in the families' homes and aimed at assessing the quality of maternal behavior during naturalistic mother-infant interactions. The visit was structured along the guidelines provided by Pederson and Moran (1995), aimed at challenging the mother's capacity to divide her attention between competing demands, thus reproducing the natural conditions of caring for an infant. The home-visit protocol was purposely designed to create a situation where maternal attention was being solicited by both research tasks and infant demands, which placed the dyad in a challenging situation, likely to activate both the infant's attachment system and the mother's caregiving system in response. This 90-minute visit included child-centered tasks, a brief interview with the mother, a videotaped mother-infant interactive sequence, and questionnaires that mothers had to complete while the infant was *not* looked after by the research assistant. When another adult was present in the home at the time of the visit, s/he was asked not to stay in the room, so as not to provide distraction or assistance to the infant. If other children were present but no other adult was there to look after them, another research assistant came along, and played with the other children in a separate room, so that observations could focus on the target mother-infant dyad. Observations performed throughout this visit were used to rate maternal sensitivity with the Maternal Behavior Q-Sort (MBQS; see below). Graduate observers, trained following Pederson and Moran's recommendations (below), conducted these ratings.

The second visit also took place in families' homes and was structured in the same way as the T1 visit, which allowed for the assessment of infant attachment security with the Attachment Behavior Q-Sort (AQS; see below). As with the MBQS, ratings were based on observations performed throughout the visit by trained research assistants (different from the T1 raters). This visit also included assessments of infant perspective-taking abilities and executive functioning as described below. For both the first and second visits, mothers chose a time during the day when they estimated that their child was well-rested and could participate in the assessment procedures. Nonetheless, research assistants remained sensitive to the pace of task administration for each child and took breaks as needed. Finally, families were given instructions for their infant to wear an actigraph monitor and asked to complete a diary of child sleep for a 72-hour period following the visit.

In order to maximize the reliability of the home observations, which were central to this study, we followed Pederson and Moran's (1995) recommendations for training our home visitors. Research assistants first attended a two-day training workshop on techniques of home visiting and structured observation of mother-infant interactions. They reviewed several videotapes to practice coding the MBQS and the AQS. The assistants then performed their first few home visits with a more experienced colleague, and the two completed the MBQS or the AQS together. When the junior home visitors were ready to lead home visits independently, the next two or three visits were followed by a debriefing session with an experienced graduate student, to review the salient elements of the visit before scoring the MBQS or the AQS. Inter-rater reliability testing took place only after assistants had succeeded in this training.

### 5.3. Measures

**Maternal sensitivity** was assessed at T1 using the Maternal Behavior Q-Sort (MBQS; Pederson & Moran, 1995), a 90-item measure of the quality of maternal behavior during mother-infant interactions. Home visitors observed maternal behaviors throughout the visit and rated the MBQS immediately thereafter, based on the entire observation period. Items describing

potential maternal behaviors are sorted into nine clusters, ranging from very similar to very unlike the observed mother's behaviors. The observer's sort is then correlated with a criterion sort representing the prototypically sensitive mother, which is provided by the developers of the instrument. Sensitivity scores can thus vary from −1 (least sensitive) to +1 (prototypically sensitive). Thirteen home visits (20.6%) were randomly chosen to be conducted by two research assistants, who completed the MBQS independently. Agreement between the two raters' sorts was very good, ICC = .86.

The MBQS is significantly related to other measures of maternal behavior, such as the HOME Inventory and the Ainsworth scales (see Pederson & Moran, 1995), and shows good temporal stability (Bailey, Moran, Pederson, & Bento, 2007; Tarabulsy et al., 2008). Its construct validity is demonstrated by meta-analytic data showing its excellent predictive capacity with respect to child attachment security (Van IJzendoorn, Vereijken, Bakermans-Kranenburg, & Riksen-Walraven, 2004). MBQS scores also relate to subsequent child cognitive and socio-emotional functioning (Bernier et al., 2012; Bordeleau et al., 2012a; Lemelin, Tarabulsy, & Provost, 2006).

**Infant sleep**. When they were aged 2 years (T2), infants wore an actigraph monitor (Mini-Mitter® Actiwatch, Respironics) for a 72-hour period, and mothers were asked to complete a diary of their infant's sleep during the same period. An actigraph is a small wireless device that allows for continuous recording of body movements. An accelerometer detects wrist or ankle activity. The signal is integrated over a 30-second epoch and a value expressed as "activity count" is recorded. Scoring algorithms are then used to identify sleep or wake states from activity counts. Numerous reports have shown actigraphy to provide valid measures of sleep in infants and young children (e.g., Acebo et al., 1999; So, Buckley, Adamson, & Horne, 2005; Sung, Adamson, & Horne, 2009). However, actigraphy tends to overestimate night awakenings (Meltzer, Montgomery-Downs, Insana, & Walsh, 2012). A secondary "smoothing" algorithm, developed specifically to address the problem of overestimation of night waking (Sitnick, Goodlin-Jones, & Anders, 2008), was therefore applied to the nighttime data. This algorithm has been validated against videosomnography (Sitnick et al., 2008) and home-based polysomnography (PSG; Bélanger, Bernier, Paquet, Simard, & Carrier, 2013). Sleep data were collected on weekday (31 families) or weekend (32 families) nights. Sleep outcomes did not differ as a function of the moment of data collection (weekdays/weekends; $t(61)$ from −.62 to 1.76, *ns*).

Young children often feel uncomfortable wearing an actigraph on their wrist. Therefore, mothers were informed that their child could wear the actigraph either on the non-dominant wrist or the ankle, and asked to report this information on the sleep diary (81% of the children wore the actigraph on the ankle). Location of the monitor does not influence data among 2–5 year-old children: this model of actigraph shows good to high agreement (77% to 98% across variables) with PSG for this age group, regardless of location (Bélanger et al., 2013). Two indicators of sleep, chosen for the developmental reasons outlined in the introduction and for their demonstrated correspondence to PSG estimates when using this model of actigraph at the same developmental period (Bélanger et al., 2013), were derived and averaged across the three assessment days: nighttime sleep duration (total time asleep between sleep onset and sleep offset) and proportion of nighttime sleep to total sleep (nighttime sleep duration/(nighttime sleep duration + daytime sleep duration) × 100).

The main function of the sleep diary is to cross-check the actigraphy data. Hence, data of families for whom actigraphic data showed poor correspondence with diaries (e.g., child detected as asleep by actigraphy but reported to be up) were discarded. Actigraphic data were also discarded when the diary indicated that the child was not wearing the actigraph (bath, swimming), or was asleep in a moving object (car, stroller). Sleep data were available for three nights for 49 participants, two nights for 9 participants, and one night for 5 participants. Sleep data were missing because children refused to wear the actigraph for a second or third day, because artifacts were identified in the actogram, or because the diary indicated that the actigraphic data would be invalid, as described above. There was no significant difference according to the number of nights with available actigraphic data on nighttime sleep duration ($F(2,61) = .06$, $p = .94$) or proportion of nighttime sleep ($F(2,61) = .49$, $p = .62$). All available data were therefore used for each child (note, however, that the results were essentially the same when analyses were run with only those 49 children with three nights of actigraphy).

**Infant attachment security** was assessed at T2 using the Attachment Behavior Q-Sort (AQS; Waters, 1995), completed immediately after the home visit. The AQS comprises 90 items describing potential child behaviors. The sorting procedure is the same as with the MBQS, except that the focus is on child rather than maternal behavior. Thus, like sensitivity scores, attachment scores can vary from −1—most insecure to +1—prototypically secure. Inter-rater reliability was conducted for 16% of the dyads and was found to be adequate, ICC = .73. The AQS shows good temporal stability (Tarabulsy et al., 2005), and meta-analytic data show that it possesses excellent construct validity, with attachment scores converging with maternal sensitivity, attachment security assessed with the Strange Situation, and child adaptation (Van IJzendoorn et al., 2004).

**Executive functioning.** The executive tasks, administered at T2, were chosen based on Carlson's (2005) empirically-derived measurement guidelines with the aim of maximizing detection of individual differences in three dimensions of EF: working memory, inhibitory control, and set-shifting (flexibility). Psychometric research indicates that these tasks provide reliable measurement of individual differences at age 2 and that these differences are stable across time (Carlson, 2005). Like the theory of mind tasks presented below, all EF tasks were video-recorded for later coding.

*Spin the pots* (Hughes & Ensor, 2005). In this task assessing working memory, children were asked to search for stickers that were hidden in opaque pots, subsequently covered and rotated 180°. Six stickers were hidden in eight pots of very different visual appearances, thus leaving two pots empty. Each time a sticker was found, it was given to the child and all eight pots were covered and rotated 180° again. Therefore, as children found stickers, there was an increasingly large number of empty pots on the tray. The score was calculated as 16 (which is the maximum number of trials allowed) minus the number of errors made.

**Table 1**
Descriptive statistics for the key study measures.

| | Minimum | Maximum | Mean | Standard deviation |
|---|---|---|---|---|
| Maternal sensitivity | −.60 | .89 | .66 | .28 |
| Nighttime sleep duration (h) | 6.49 | 11.31 | 9.41 | 1.01 |
| Proportion of nighttime sleep | 57.22 | 97.69 | 78.82 | 7.43 |
| Attachment security | −.29 | .80 | .49 | .27 |
| Spin the pots | 4 | 16 | 9.73 | 3.35 |
| Shape stroop | 0 | 3 | 1.41 | 1.10 |
| Baby stroop | 0 | 2 | .33 | .61 |
| 5-second delay | 0 | 5 | 4.61 | 1.01 |
| 10-second delay | 1 | 10 | 8.90 | 2.22 |
| 15-second delay | 0 | 15 | 12.20 | 4.99 |
| 20-second delay | 0 | 20 | 13.98 | 7.58 |
| Visual perspective taking | 4 | 16 | 12.16 | 3.01 |

*Delay of gratification* (Kochanska, Murray, & Harlan, 2000). In order to assess inhibitory control, the experimenter placed a present under a transparent cup and asked children to wait until she rang a bell before retrieving it. Four trials were conducted, where the child had to wait 5, 10, 15, and then 20 s. Scores were the number of seconds waited on each trial.

*Shape stroop* (Kochanska et al., 2000). This task taps into inhibitory control and set-shifting. Children were first shown six cards depicting three small and three large fruits, and were asked to point to each in turn to ensure they knew the names and sizes of the fruits. They were then shown three cards each depicting one of the small fruits embedded in one of the larger ones, and asked to point to each of the small fruits in turn (e.g., "Show me the *small* banana"). The score consisted of the number (0–3) of small fruits correctly pointed to.

*Baby stroop* (adapted from Hughes & Ensor, 2005). Children learned a rule for feeding two dolls, feeding the "mommy" doll with a larger spoon and the baby doll with a smaller spoon. As soon as the child clearly understood the rule, it was reversed such that the larger doll had to be fed with the smaller spoon, and vice-versa. This task thus calls upon inhibitory control and set-shifting. Scores ranged from 0 to 2.

**Theory of mind: visual-perspective taking** (Carlson, Mandell, & Williams, 2004). This task, also administered at T2, evaluated children's capacity to understand under what conditions another person can see an object. The experimenter presented one toy at a time to the child, asking him/her to show it to his/her mother. Four toys were presented to the child in turn, in conditions where the mother could not immediately see the toy. For the first toy, the mother was asked to close her eyes and not to open them unless her child asked her to. For the second toy, the mother had to put her hands in front of her eyes, the third time, she needed to turn her back to the child, and for the fourth toy, there were no particular instructions for the mother but the child had to show her a toy that had only one side. Thus, in all conditions, the mother could not see the toy unless her child implemented a correction, such as asking her to open her eyes, to remove her hands from before her eyes, walking around her so as to face her, or turning the toy around, face toward the mother. Child performance on each of the four tasks was scored on a 4-point scale adapted from Carlson et al. The child obtained 1 point if he/she didn't show the toy to his/her mother or dropped it near her, 2 points if he/she held the toy near the mother but did not make the necessary correction for her to see the object, 3 points if a partial correction was initiated but was abandoned before the mother could see the object, and 4 points if a complete correction was made and the toy was seen by the mother. Scores could thus vary from 4 to 16. This task allows for reliable measurement of individual differences in 2-year-olds' perspective-taking abilities and shows convergent validity with other measures of theory of mind (Carlson et al., 2004).

## 6. Results

### 6.1. Preliminary analyses

Table 1 presents the descriptive statistics for the core study variables. All presented satisfactory variability, although performance on delay of gratification trials was generally very good. No outliers were detected. In order to reduce the probability of Type-I errors and compute reliable aggregate estimates, EF task scores were submitted to a principal component analysis, which yielded a two-factor solution (*Eigen* values > 1.0) representing 55.4% of the total variance. These two factors were submitted to an oblique rotation. Factor loadings for 10-second delay (.83), 15-second delay (.82), 5-second delay (.79), and 20-second delay (.72) suggest that the first factor taps impulse control, whereas the second factor appears to represent working memory, set-shifting and inhibitory control (Conflict-EF): spin the pots (.89), shape stroop (.67), and baby stroop (.51). No cross loadings were observed. Studies of EF in young children have often found similar factor structures (e.g., Carlson et al., 2004; Conway & Stifter, 2012). Given that the current factor structure reproduced these two documented dimensions, two averaged standardized scores were computed and used in further analyses.

Next, we examined the extent to which socio-demographic factors (child gender and age, maternal and paternal age and education, and family income) were related to the dependent variables (child attachment, conflict-EF, impulse control, and perspective-taking abilities). A rare case of consensus in the literature is that the power of prediction is higher when SES components are combined rather than taking each indicator singly (White, 1982). In line with this, and given the correlations (ranging from .50 to .57) between maternal and paternal education and family income, these three variables were standardized and averaged into a composite index of SES. SES was unrelated to the dependent variables ($r$'s = .07 to .16, *ns*). It was, however, related to maternal sensitivity, $r$ = .30, $p$ = .02, and will therefore be considered in analyses to ensure conservative predictions. Child age in months at T2 was unrelated to performance on outcome variables ($r$'s = from .05 to .10, *ns*), and therefore not considered further. Likewise, child gender was unrelated to other study variables (all $t$'s < 1.26, *ns*), and not retained in the main analyses.

Table 2 presents the bivariate correlations between study variables. The sleep indicators were unrelated to maternal sensitivity, $r$'s < .13, *ns*. This independence of the predictor and the moderators makes for more readily interpretable interaction terms (Dearing & Hamilton, 2006).

**Table 2**
Zero-order correlations among key study variables.

| | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| 1. Maternal sensitivity | −.01 | .13 | .40*** | .11 | .21t | .15 |
| 2. Nighttime sleep duration | – | .35** | .03 | .08 | .05 | −.02 |
| 3. Proportion of nighttime sleep | | – | .16 | .25* | .06 | .29* |
| 4. Attachment security | | | – | .31** | .08 | .07 |
| 5. Conflict-EF | | | | – | .28** | .22t |
| 6. Impulse control | | | | | – | .08 |
| 7. Perspective-taking | | | | | | – |

t $p < .10$.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

**Table 3**
Regression analyses predicting infant attachment security, conflict-EF, impulse control, and visual perspective-taking from maternal sensitivity, infant sleep, and their interactions.

| Predictors | | Infant nighttime sleep duration | | | Infant proportion of nighttime sleep | | |
|---|---|---|---|---|---|---|---|
| | | $R^2$ | $R^2$ change | $\beta$ | $R^2$ | $R^2$ change | $\beta$ |
| | Criterion: attachment security | | | | | | |
| 1. | Family SES | 20.5% | 2.8% | .04 | 18.3% | 1.3% | .10 |
| 2. | Maternal sensitivity | | 12.3% | .39** | | 16.7% | .37** |
| | Infant sleep | | | −.01 | | | .25t |
| 3. | Sensitivity × sleep | | 5.4% | .24* | | .3% | .06 |
| | Criterion: conflict-EF | | | | | | |
| 1. | Family SES | 6.0% | .4% | .03 | 15.1% | .5% | .16 |
| 2. | Maternal sensitivity | | 1.7% | .14 | | 7.9% | .21 |
| | Infant sleep | | | −.07 | | | .27* |
| 3. | Sensitivity × sleep | | 3.9% | .20t | | 6.7% | .28* |
| | Criterion: impulse control | | | | | | |
| 1. | Family SES | 5.4% | .0% | .06 | 6.4% | .1% | .06 |
| 2. | Maternal sensitivity | | 5.3% | .22t | | 6.2% | .27* |
| | Infant sleep | | | .11 | | | .05 |
| 3. | Sensitivity × sleep | | .1% | −.03 | | .2% | .05 |
| | Criterion: visual perspective-taking | | | | | | |
| 1. | Family SES | 11.0% | 1.8% | .22t | 16.9% | 1.6% | .10 |
| 2. | Maternal sensitivity | | 6.4% | .28* | | 9.5% | .33* |
| | Infant sleep | | | .04 | | | .22 |
| 3. | Sensitivity × sleep | | 2.8% | .17 | | 5.8% | .26* |

*Note*: The regression coefficients shown are those in the final models, while accounting for all other main and interactive effects.
t $p < .10$.
* $p < .05$.
** $p < .01$.

*6.2. Main analyses*

We next examined the interactive effects of early maternal sensitivity and infant current sleep in the prediction of infant attachment security, conflict-EF, impulse control, and perspective-taking abilities. These outcomes were submitted to distinct regression equations. In each equation, family SES was entered in a first block. Maternal sensitivity and one of the sleep variables (centered) were entered in a second block, followed by their interactive product in a third block. The results of these analyses are presented in Table 3. Maternal sensitivity interacted with nighttime sleep duration ($\beta = .24$, $p = .04$) in predicting infant attachment security. Furthermore, sensitivity interacted with proportion of nighttime sleep in the prediction of conflict-EF ($\beta = .28$, $p = .04$) and perspective-taking abilities ($\beta = .26$, $p = .05$).

The three significant interactions were decomposed following Preacher, Curran, and Bauer's (2006) guidelines, plotting fitted regression lines at high (+1 SD) and low (−1 SD) values of the moderator (proportion or duration of nighttime sleep). All interactions revealed the same phenomenon. They are depicted in Fig. 1, based on high (+1 SD) and low (−1 SD) levels of maternal sensitivity. Higher maternal sensitivity was related to better performance on tasks of conflict-EF and perspective-taking ($\beta = .78$, $p = .04$ and $\beta = 1.23$, $p < .001$, respectively) among infants getting greater proportions of their sleep during the night. In contrast, maternal sensitivity was unrelated to conflict-EF or perspective-taking abilities ($\beta = .03$, $p = .93$ and $\beta = .37$, $p = .29$) among infants getting lesser proportions of their sleep during the night. Likewise, higher maternal sensitivity was related to greater attachment security for infants who slept longer at night ($\beta = .62$, $p = .001$), but was unrelated to attachment security for those with shorter nighttime sleep duration ($\beta = .13$, $p = .44$).

Given that many children still nap at 2 years, we ran exploratory analyses with duration of daytime sleep as a moderator. As expected given the unclear meaning of daytime sleep in toddlerhood (Dionne et al., 2011), no significant interactions were found in predicting attachment, EF, or perspective-taking abilities.

## 7. Discussion

The aim of this study was to investigate the moderating role of infant sleep in the prospective relations between early maternal sensitivity and three important indicators of functioning at age 2: attachment security, theory of mind, and

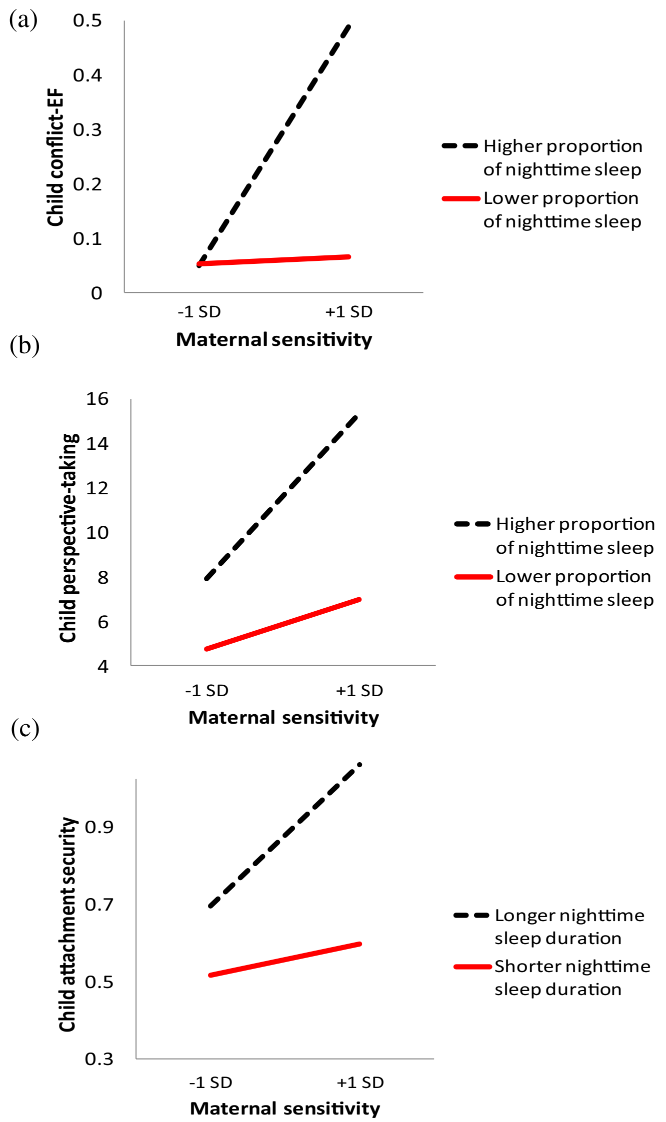


**Fig. 1.** (a) Links between conflict EF at age 2 and maternal sensitivity at age 1 for infants with higher and lower proportion of nighttime sleep at age 2. (b) Links between perspective-taking abilities at age 2 and maternal sensitivity at age 1 for infants with higher and lower proportion of nighttime sleep at age 2. (c) Links between attachment security at age 2 and maternal sensitivity at age 1 for infants with longer and shorter nighttime sleep duration at age 2.

executive functioning. It was expected that the links between maternal sensitivity and outcomes would be more pronounced among infants showing greater nighttime sleep duration and/or greater proportions of nighttime sleep. The results showed that maternal sensitivity was related in expected ways to attachment security only among infants who got more sleep at night, and to conflict-EF and perspective-taking abilities for those who got greater proportions of their sleep at night.

Overall, these results support the hypothesis that certain aspects of concurrent sleep may foster the expression of the levels of socio-emotional and cognitive functioning that are made possible by infants' earlier exposure to maternal sensitivity. In contrast, the non-significant links between maternal sensitivity and outcomes among infants showing shorter night sleep duration or lower night sleep proportion suggest that poor sleep might interfere with the developmental processes linking caregiving to child adaptation. Thus, although the current design precludes causal inference, the results are consistent with the notion that only infants for whom nocturnal sleep was longer or more prominent reaped the usual benefits of maternal sensitivity. That this pattern of results was observed in three important spheres of functioning (attachment, theory of mind, executive functioning) suggests that it might be a broad phenomenon with implications for other domains of development. Hence, while there is evidence that sleep plays a direct role in infants' and children's behavioral, socio-emotional, and cognitive functioning, the current findings add to emerging evidence (Bordeleau et al., 2012a; El-Sheikh et al., 2010) in suggesting that sleep could also play an indirect role, by potentiating (or dampening) the effects of other well-documented influences on child development, such as parent-infant relations.

Interestingly, the graphic displays of the interactions appear to suggest a dual-protection pattern, such that infants who showed more adequate sleep and were exposed to higher levels of maternal sensitivity were those with the highest predicted levels of the outcomes, whereas the putative dual-risk associated with poor sleep and low maternal sensitivity (which would be hypothesized by a diathesis-stress model) appeared considerably less clear. This suggests that adequate sleep can carry true benefits, not only protect against negative effects. More generally, the current results support one form of interplay between child sleep and parenting: an interactive effect revealing that a positive aspect of maternal behavior plays its expected beneficial role mostly when child nocturnal sleep is longer or more prominent. It is conceivable, however, that the nature of the interaction could vary when considering the other side of the coin, namely the detrimental effects of negative parenting (such as patent control or intrusiveness, rather than sheer absence of positive behaviors). In such a case, and in line with the diathesis-stress model, one may argue that poor sleep could exacerbate matters by making children fatigued and irritable, and hence, more vulnerable to negative parenting (see El-Sheikh et al., 2010). If this were so, and in contrast to the current findings, one would note especially *pronounced* relations between negative parenting and child difficulties (for instance, internalizing and externalizing problems) among the groups of children showing *poorer* sleep. In fact, some studies did find this specific pattern of interactive effects when studying negative family influences (e.g., marital conflict), child maladjustment, and other aspects of child biological functioning (e.g., parasympathetic system functioning): the effects of negative family influences are exacerbated by deficient physiological functioning (e.g., El-Sheikh, Harger, & Whitson, 2001; El-Sheikh & Whitson, 2006). Thus, while it is undisputable that adequate sleep is likely to play a protective role, and poor sleep to be a risk factor, this should have different implications for statistical interactions as a function of the specific aspects of the environment that are investigated. Overall, the hypothesis that the duration, maturity, or quality of children's sleep would modulate their processing and responses to environmental influences seems increasingly sound. The exact forms of such interactions, however, should depend on what constitutes risk and protection given the specific predictors and outcomes considered.

The identification of the exact aspects of sleep that could potentiate or dampen the links between parenting and infant functioning is a matter of further empirical investigation. Tentative hypotheses can nonetheless be proposed. It is well documented that important cellular and biochemical mechanisms favoring brain plasticity take place during sleep (see Buchmann et al., 2011; Poe, Walsh, & Bjorness, 2010). Studies have also repeatedly shown that sleep affects neuronal organization associated with learning and new experiences (Gais et al., 2007; Rauchs et al., 2008). These mechanisms are likely to support the consolidation of daytime experience. In addition, they contribute to homeostasis, and could thereby favor next-day alertness through their restorative properties, hence supporting children's propensity to manifest the capacities made possible by their earlier experiences. In other words, sleep may contribute to proper functioning of the neural structures that are essential to children's developmental competence, while also making young children more refreshed and thus better equipped, emotionally and behaviorally, to display these levels of competence. A promising avenue for future research lies in the investigation of sleep architecture to pinpoint which aspects of sleep might fulfill these functions. Of interest, recent models propose that REM (rapid-eye-movement) and non-REM sleep may have unique contributions to different types of learning experiences and emotion regulation (Walker & Stickgold, 2010; Walker & Van der Helm, 2009). Furthermore, slow-wave activity (spectral power between .5 and 4.0 Hz during non-REM sleep) has been proposed to contribute to the regulation of cortical synaptic strength (Ringli & Huber, 2011). The use of PSG will be invaluable in determining which of these or other features of sleep may contribute to making infants more (or less) receptive to positive and negative caregiving influences.

For the reasons outlined in the introduction, we chose to set up the study as an examination of the moderating role of child sleep in the well-known associations between maternal sensitivity and child outcomes. Recall, however, that the interpretation of statistical interactions depends on the research objectives. To address our research questions, we chose to position maternal sensitivity as the predictor and child sleep as the moderator. However, this is statistically equivalent to a model in which sleep would be the predictor and sensitivity, the moderator. Hence, our results could just as well be interpreted as suggesting that maternal sensitivity moderates the links between sleep and child outcomes and in fact, many studies consider sensitivity as a buffer against biological adversity (e.g., Barry, Kochanska, & Philibert, 2008). In our specific case, though, the graphed interactions appear to suggest, again, a dual-benefit pattern rather than a buffering effect: at low levels of maternal sensitivity (left-hand side of graphics), poorer and better sleepers show comparable outcomes, and it is at high levels of maternal sensitivity that sleep appears to play its expected beneficial role.

When considering infant attachment, conflict-EF, and perspective-taking, only one of the six interactions tested (that pertaining to sleep proportion and attachment) stood in clear contrast to the others. The others that failed to reach statistical significance were comparable in direction to the significant interactions, thus yielding a reasonably consistent pattern of results across these three outcomes. In contrast, the interactions between sensitivity and sleep explained almost no variance in child impulse control. While this may be meaningful conceptually, it may also be a random pattern (perhaps related to the lower variability noted above for the delay of gratification trials). Given the absence of other studies that have examined multiple outcomes as resulting from interactions between parenting and infant or child sleep, it would be extremely speculative to try and adjudicate between these two possibilities. It does seem reasonable, however, to note that while child sleep is beginning to emerge as a potentially meaningful moderator of family influences on children, this may not be the case with all aspects of child functioning.

Another set of non-significant findings that may merit attention pertains to the lack of associations between maternal sensitivity and the two sleep indicators (Table 2). As mentioned earlier, this allows for clearer interpretation of ensuing

interaction terms. Beyond this statistical advantage, the lack of association between maternal sensitivity and infant sleep may be worthy of conceptual attention, as it is in fact consistent with the results of prior studies. As far as we know, research has yet to find positive relations between observed maternal sensitivity and infant sleep in non-clinical samples. The studies that did find theoretically-expected links between parenting and typically-developing children's sleep were conducted with preschoolers and school-age children (Adam, Snell, & Pendry, 2007; Bell & Belsky, 2008; Bordeleau, Bernier, & Carrier, 2012b; Spilsbury et al., 2005). Studies examining infants' sleep found non-significant or, in some cases, negative relations with maternal sensitivity, whether using maternal reports (Dearing, McCartney, Marshall, & Warner, 2001; Weinraub et al., 2012) or actigraphy (Scher, 2001) to assess sleep. Although one cannot prove the null hypothesis, especially with relatively small samples, we submit that the repeatedly found absence of association between maternal sensitivity and infant sleep may be meaningful conceptually and developmentally.

Limitations of this study need to be noted, first the modest sample size that limited statistical power, which is unfortunate in the context of the examination of interactions. At the same time, this sample appears to be one of the largest documented groups of typically-developing toddlers with actigraphy data and developmental outcomes. This paucity of sleep research with 2–3-year-olds, compared to very young infants or older children, has been noted by others (Galland, Taylor, Elder, & Herbison, 2012; Meltzer et al., 2012; Scher et al., 2010). Also, actigraphy data were available for one to three days only. Although this is far from unusual when working with young children (Gnidovec, Neubauer, & Zidar, 2002; Harrison, 2004; Sazonov, Sazonova, Schuckers, & Neuman, 2004; Scher et al., 2010; So et al., 2005; Ward et al., 2008), it is preferable to use at least five days (Acebo et al., 1999). We also assessed infant sleep only once, concurrently to the outcomes. While this allowed us to test whether concurrent sleep can support infants' capacity to display the levels of functioning expected from their prior caregiving experiences, an ideal design would have assessed infant sleep also at the time when maternal sensitivity was assessed, in order to address the equally important question of sleep as a factor magnifying or interfering with infants' propensity to absorb ongoing caregiving influences. In fact, given that both sensitivity and sleep were assessed once only, we cannot rule out alternative explanations of the findings, for instance that it is mainly concurrent sleep that moderates the effects of maternal sensitivity, or even that earlier sleep sets the stage for a developmental process which will subsequently moderate the effects of later-occurring sensitivity. In other words, the temporal order of assessments should not be taken as unambiguous demonstration that the underlying developmental phenomenon follows the same sequence. Furthermore, this is a well-educated sample, and the findings may not generalize to lower-SES families. Finally, although we chose to address sleep as a biological variable in developing this study's rationale, this is not so clear-cut: while undoubtedly dependent on neural maturation (Jenni & LeBourgeois, 2006) and closely related to other indicators of biological functioning (Scher et al., 2010), child sleep is also associated with several different aspects of the family environment (e.g., Bernier, Bélanger, Bordeleau, & Carrier, 2013; Teti, Kim, Mayer, & Countermine, 2010). Hence, the exact nature of the interplay between the family environment, child sleep, and child developmental competence is likely to be much more complex than portrayed here.

These limitations must be appraised in the context of this study's unique features. As noted above, the sample size is excellent for actigraphic data with 2-year-olds. Furthermore, maternal reports are frequently used as convenient proxies for maternal caregiving behavior, child sleep, and/or child outcomes, often in cross-sectional designs. The current study is, to our knowledge, the first to present longitudinal predictions based entirely on observational home-based data for both parenting and infant outcomes, along with an objective measure of sleep. Overall, the findings of this study suggest one way in which family factors can intersect with infant sleep: an interactive effect by which prior positive caregiving experiences play their expected beneficial role mostly when infants get more adequate sleep. More generally, we submit that investigating interactions between parenting and infant sleep may explain more variability in developmental outcomes than studying either in isolation, or even than examining their additive effects. This is likely to shed light not only on the different ways in which sleep can affect infant development, but also on the complex relations between the early caregiving environment and children's developmental pathways.

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